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Self-generated neural activity: models and perspective

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The brain is autonomously active and this self-sustained neural activity is in general modulated, but not driven, by the sensory input data stream [1,2]. Traditionally one has regarded this eigendynamics as resulting from inter-modular recurrent neural activity [3]. Understanding the basic modules for cognitive computation is, in this view, the primary focus of research and the overall neural dynamics would be determined by the the topology of the inter-modular pathways. Here we examine an alternative point of view, asking whether certain aspects of the neural eigendynamics have a central functional role for overall cognitive computation [4,5].

Transiently stable neural activity is regularly observed on the cognitive time-scale of 80–100 ms, with indications that neural competition [6] plays an important role in the selection of the transiently stable neural ensembles [7], also denoted winning coalitions [8]. We report on a theory approach which implements these two principles, transient-state dynamics and neural competition, in terms of an associative neural network with clique encoding [9].

A cognitive system [10] with a non-trivial internal eigendynamics has two seemingly contrasting tasks to fulfill. The internal processes need to be regular and not chaotic on one side, but sensitive to the afferent sensory stimuli on the other side. We show, that these two contrasting demands can be reconciled within our approach based on competitive transient-state dynamics, when allowing the sensory stimuli to modulate the competition for the next winning coalition. By testing the system with the bars problem, we find an emerging cognitive capability. Only based on the two basic architectural principles, neural competition and transient-state dynamics, with no explicit algorithmic encoding, the system performs on its own a non-linear independent component analysis of input data stream. The system has rudimentary biological features. All learning is local Hebbian-style, unsupervised and online. It exhibits an ever-ongoing eigendynamics and at no time is the state or the value of synaptic strengths reset or the system restarted; there is no separation between training and performance. We believe that this kind of approach – cognitive computation with autonomously active neural networks – to be an emerging field, relevant both for system neuroscience and synthetic cognitive systems.

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